RODENTS AND RECLAMATION IN THE IMPERIAL VALLEY[1]

By Joseph Dixon

Human occupancy of a region always results in great changes in the animal life therein. Species of mammals, for instance, that afford man meat, hides, or fur are almost sure to decrease in number, whereas other species, including some that are harmful to man's interests, frequently increase. In the case now under discussion, both classes of animals are represented.

The recent reclamation of the major part of the Imperial Valley, which occupies the southern portion of the Colorado Desert in the southeastern corner of California, is of unusual interest in many ways, but particularly so in connection with its widespread influence on the distribution and abundance of the rodents of that region. The area involved consists of the entire delta of the Colorado River. This delta is one hundred miles in length and has an average width of thirty miles; it extends from Salton Sea on the north to the Gulf of California on the south, and from the Cocopah Mountains on the west to Arizona and Sonora on the east. About one half of the delta lies within the United States, whereas the other half lies south of the Mexican boundary in Lower California and Sonora.

That part of the delta region lying within the Imperial Valley in the United States is practically all below sea level. From surveys made in 1915 the elevation of the Imperial Valley was found to vary from sea level at Calexico to 234 feet below sea level at Salton Sea. In Lower California nearly all of the delta is above sea level. The crest or divide of the delta lies several miles south of the International Boundary.

The Colorado Desert, including the delta region, is characterized by marked aridity and extremely high summer temperature. Extensive areas on both the east and west margin of the Imperial Valley are occupied by hundreds of sand dunes. The rich alluvial soil of the delta is over one hundred feet in depth for hundreds of square miles. Previous to the construction of the irrigation system the Alamo and New Rivers, both being overflow channels of the Colorado River, were the only waterways of any size and importance traversing the northern half of the delta. Both of these were intermittent rather than permanent streams.

[1] Contribution from the University of California Museum of Vertebrate Zoology.

Under the original desert conditions only true desert vegetation flourished in Imperial Valley and much of the best land of the delta was covered with creosote-bush, arrow-weed and quail-brush (*Atriplex*). Mesquite was most common in sandy areas where it helped in the formation of sand dunes. Cottonwood, willow, cat-tails, cane and other riparian trees and plants were restricted to sloughs along the overflow channels. Under true desert conditions in the Colorado Delta certain rodents were closely associated with certain plants or certain types of ground. For example, the pallid muskrat (*Ondatra zibethica pallida*) and Sonora beaver (*Castor canadensis frondator*) were confined to the river, ponds, and other permanent waterways. The western desert cottonrat (*Sigmodon hispidus eremicus*) and desert harvest mouse (*Reithrodontomys megalotis megalotis*) were typical inhabitants of the sedge or tule along the banks of streams. The Colorado Valley woodrat (*Neotoma albigulà venusta*) was a characteristic dweller of mesquite thickets. The Yuma round-tailed ground squirrel (*Citellus tereticaudus*) and allied kangaroo rat (*Dipodomys merriami simiolus*) were two typical inhabitants of the dry sand dunes, while the Imperial Valley gopher (*Thomomys perpallidus albatus*) was found sparingly in sandy places where sufficient food could be had. The gopher, being unable to forage about for any great distance above ground, had the most restricted distribution of any of the mammals.

Having ascertained conditions as they existed prior to the reclamation of Imperial Valley, the changes that have taken place there during the past fifteen years may now be noted. One of the first and most important changes was the construction of a network of irrigation canals. These vary in width from four to one hundred and sixty feet; their aggregate length runs into hundreds of miles, there being over three hundred miles of main canals to say nothing of the laterals. The removal of the native vegetation and the breaking up and cultivation of hundreds of thousands of acres soon followed. The levelling of the land so that all parts of a field might be flooded during the frequent summer irrigation came next. Alfalfa and cotton fields now mark the former site of extensive stretches of creosote and other desert vegetation. Man's occupancy of the region also resulted in the destruction of many of nature's best rodent destroyers. This reduction, by man, in the numbers of snakes, coyotes, wild cats, kit foxes, coons, badgers, hawks, and owls has especially assisted certain rodents, such as gophers, in their rapid increase, since it removed one of their most important natural checks.

The three most important conditions necessary for the successful life of any species of animal, as pointed out by Grinnell in his Colorado River Report, 1914, are adequate food supply, safe breeding dens and places for temporary refuge in extremity. A sufficient supply of the proper sort of food is the first requirement. Unless safe breeding dens are availabe the future generations of a species are placed in jeopardy. To a kangaroo rat that is being closely pursued by a hungry kit fox the nearness of a protecting burrow may be a question of life or death. With these esssentials of rodent existence in mind, let us note the effect of the recent radical changes in Imperial Valley on the various species involved.

Field work carried on by the writer in March and April, 1921, in the Imperial region on both sides of the International Boundary, showed that the rodent population of that region could be readily divided into two classes. The first class consists of rodents that tend to be driven out by reclamation. Belonging to this category are the round-tailed ground squirrel, Colorado Valley woodrat, kangaroo rat and pocket mouse.

The other class is composed of species that have benefited by, and increased as a result of, the reclamation of desert lands. The harvest mouse, cotton rat, beaver, muskrat and gopher belong to this second class. The species that are driven out by reclamation are those that are most abundant in the sand dune areas. The true desert rodents are able to live without water other than that obtained from the food that they eat; as a matter of fact, irrigation drives them out. With the one exception of the gopher, the rodents that have increased under reclamation are all water or stream-side dwellers.

Reclamation in Lower California has not been carried on as rapidly or as extensively as it has on the American side, and as a result large areas still remain where wholly natural conditions prevail. An excellent chance was thus afforded for observing original conditions and for seeing reclamation forces in actual operation. The immediate results of different stages of reclamation and irrigation were also observed. In one instance, an area one mile long and one-half mile wide lying just south of the border and eleven miles east of Mexicali was studied in detail. One half of this selected area was covered by original mesquite crowned sand dunes surrounded by patches of arrow-weed and quail brush. The rest of the tract had recently been or was being cleared, leveled, and planted to cotton or alfalfa. The ground squirrels, pocket mice, kangaroo rats and woodrats that had formerly inhabited the

land were thus forced to seek protection in the sheltering mesquite thickets of the adjoining sand dunes. Periodic flooding of the fields during irrigation destroyed the burrows of such rodents as returned to their former homes in the cultivated fields. This concentration of the rodent population meant increased competition for food. At the same time the food producing area was greatly reduced especially where cotton was raised. As a result, considerable damage was done, particularly by the little squirrels (*Citellus*), to grain fields that were enclosed or bordered by mesquite thickets. Some difficulty also resulted from the burrowing of the rodents, chiefly squirrels, into sandy irrigation ditch banks between irrigations. Some ditches or levees that remained unused for a few months were thus rendered useless. The abundance of squirrels at this locality was indicated by four being caught in as many days in one trap set at the mouth of one burrow. Poisoning with barley coated with strychnine afforded temporary relief, and the gradual settlement of the land resulting in the complete removal of the sand dunes, which are being leveled into fields, means that this first class of rodents will soon be controlled and in many instances exterminated over large irrigated areas. In other words, once their food supply, breeding dens and temporary refuges, the essentials of a successful existence, are all destroyed, the rodents will cease to exist.

In considering the rodents that have increased through reclamation, we find that the construction and use of irrigation canals has been the fundamental cause of their successful battle for existence. The irrigation ditches have simply served as highways for the spread of aquatic or stream-side animals. Thus, harvest mice and cotton rats have followed down along the canal banks through Lower California from the Colorado and Alamo Rivers until they are now to be found in considerable numbers in American territory. On March 17, 1921, the writer found many well-defined runways and trapped an adult breeding male cotton rat one half mile south of the International Boundary near Allison Heading. Six harvest mice were also captured in the cotton rat runways. Extensively used cotton rat runways were also found in Imperial County on the American side of the line, so that this unwelcome rodent is now definitely known to be established in the cotton districts of Imperial Valley. It is unlikely that the harvest mouse will do any considerable damage, but the cotton rat is dangerous. In Texas and certain other gulf states cotton rats have on occasion proved very destructive to cotton and corn crops. These

rats invade cotton fields and carry off the cotton in order to secure the seed of which they are very fond. M. C. Rissinger, who for nine years has been stationed at the Eastside Heading on the main Imperial canal, reports finding a cache of cotton three feet in diameter that had been accumulated by a pair of cotton rats. The Colorado River species, therefore, has the same destructive habits as the related species of the gulf states.

The Sonora beaver, one of the largest living rodents in North America, is common in the Colorado delta. This aquatic species was formerly common all along the Lower Colorado River, but has been greatly reduced in numbers by persistent trapping. It is still abundant in the lower delta region about Volcano Lake. Beavers have invaded the Imperial Valley along two different routes: by the Alamo River and main Imperial Canal on the east side of the delta, and by way of the Black Butte Canal on the west side. At the present time there are in the neighborhood of 100 beavers in the Imperial Valley north of the International Boundary. Nearly half of these are to be found in the Alamo River, whereas the others are scattered about in the larger canals. No beaver sign was noted along New River on the American side. A thriving colony has been established for some time on the Alamo within half a mile of the center of the town of Holtville. Four recently cut willow saplings were noted at this point on March 25, 1921, and many willows, cut by beavers, have lodged against the trestle work of the Holton Interurban bridge west of Holtville. Serious breaks have already been caused by beavers burrowing into canal banks, and it is probable that other breaks will occur especially at points where the canals are built above the general land surface. Complaints of damage to canals by beavers have already been registered from the Imperial Valley, and it is likely that this damage will increase. Beavers are protected by law at all seasons in California. The state law protecting them provides that, where they are endangering the levees, permits to trap or remove them may be issued upon the proper application to the State Fish and Game Commission. However, if it were possible to remove all of the beavers from the American side of the boundary, it would only be a question of a short time until the canals would be reinfested from the breeding stock in Lower California since they have free access along all of the main canals, and beavers and muskrats do not need passports in crossing the International Boundary. While the fur of the Sonora beaver is short, pale and of poor quality, pelts of this animal sell for an average

of about eight dollars each in ordinary years, and in 1920 large raw skins sold for as much as twenty dollars. There appears to be no good reason why the beavers should not be removed wherever they are endangering the canal banks. The value of the pelt should defray the cost of the trapping if this is done at the proper season when the fur is prime and hence of greatest value.

In April, 1894, Dr. E. A. Mearns saw what he believed to be muskrat sign near Seven Wells on the Alamo (Salton) River. It is probable that a few muskrats existed along this stream prior to the construction of the Imperial irrigation system. Muskrats are now to be found in all of the main irrigation canals carrying over ten second feet of water between Salton Sea and the Gulf.

A conservative estimate based upon careful investigation places the present muskrat average population per mile as follows: Large main canals, 40; small mains, 20; Alamo River, 20; New River, 40 (and in places up to 200 per mile). In 1920, 67 muskrats were actually trapped during a single night in a distance of one mile along New River, and at least twice as many were left untrapped. Over 400 muskrats were taken by one trapper in twenty nights on the Brawley main. This trapper set his traps only one night in each place, and trapped about one mile of canal a night. In three months, W. W. Morrison and assistant, caught 1738 muskrats. From the known number of trappers and their catch it is conservatively estimated that 25,000 muskrat pelts were shipped out of the Imperial Valley during the trapping season of 1919–20. It is further believed that the catch (25,000) equaled one half the total population of muskrats.

Muskrats breed every month in the year in the Imperial Valley. Small woolly juvenals barely able to leave the nest and forage for themselves have been caught in mid-winter, and small young have been trapped during every month of the year. The bulk of the young are born between February 15 and October 30. Three and possibly more litters are raised in one year. The litters are relatively small. The average number of embryos in twenty-three pregnant females was six, with three and nine as extremes.

In the Imperial Valley muskrats live and forage entirely within the canals and other waterways. The writer has been unable to find a single instance where muskrats have gone out from the canals and injured growing crops in the adjoining fields. The favorite food of this rodent consists of the natural vegetation, such as cat-tail and grass roots, which grow along the inner banks and tend to clog up the

canals. The pallid muskrat is a typical burrow-dweller. This animal is reported to build houses in certain cat-tail swamps near Salton Sea, but none of the trappers interviewed, or the writer, has ever been able to locate such a muskrat house. It is believed that the mildness of the winter climate makes houses unnecessary to the animal. Some damage is certainly done by muskrats burrowing into canal banks, but this is comparatively slight considering the total numbers that live in the canals. The writer dug out a number of burrows in canal banks and found that much of the damage attributed to the muskrat was really being done by the gopher. None of the muskrat burrows dug out, was found to extend over half-way through the embankment. Normally these rodents begin from one-half to three feet below the water line and burrow straight into the bank. Where the bank is high close to the water's edge, the burrows were found to extend in for two or three feet and then turn abruptly upwards, ending in a nest cavity which is usually placed just above the highest high-water mark. If the bank is low, the rats sometimes burrow over the crest of the bank to reach a protecting clump of brush under which the nest is built. Where two canals are close together, muskrats sometimes burrow from one to the other. They sometimes cause breaks by burrowing around wooden head gates, through which they have been known to gnaw small holes. On the whole, damage to headgates and canal banks, due solely to muskrats, was not found to be as extensive as reported.

Prime muskrat pelts, even if from the warm Imperial Valley, have a decided value. During the trapping season of 1918–19, W. W. Morrison of Holtville caught 1124 muskrats which sold for $1,108.00, an average of nearly one dollar a pelt. The highest price received for one pelt during that season was two dollars. In 1919–20 Morrison caught 1738 muskrats which sold for $2,805.00, an average of $1.61 per pelt. Out of this lot of 1738 skins, five extra large pelts sold for five dollars each and 82, number 1 large, sold for four dollars each. At Eastside Heading, below the boundary, M. C. Rissinger secured 333 muskrats in 1919–20. These skins were mostly small, yet they sold for $456.25, an average of $1.34 per skin. Allowing a value of $1.25 a pelt, which is a very low estimate, we find that the 25,000 muskrats caught in the Imperial Valley in 1919–20 yielded the trappers an income of over $31,000.00. This record places the muskrat first as to number taken, and second in aggregate value, among the fur bearers of California for that year.

On account of numerous breaks in the canals caused by the burrows of various rodents, including the muskrat, the ditch tenders and some of the irrigation companies consider muskrats as pests, and often men are hired or paid a bounty to trap the animals. The bounty is paid not on the muskrat's head but on his tail so as not to detract from the value of the pelt. There is no gainsaying the fact that muskrats do cause a certain amount of damage. However, the evidence indicates that the damage has often been exaggerated, and investigation has shown that many of the breaks in the canals were not due to muskrats at all. In one instance an extensive break said to have cost upwards of five thousand dollars was widely reported to have been caused by muskrats, but Mr. Rouse, chief engineer of the Imperial Irrigation District, assures me that this particular break was really due to cracks in the soil of the canal bank and not to muskrats at all. However, two out of fourteen of the mutual water companies in the valley do pay a bounty of twenty-five cents on muskrat tails.

Practically all of the professional trappers wait until December, when fur is prime, before they start trapping muskrats. As one trapper said: "It doesn't pay to trap a muskrat in August for twenty-five cents when one can get $1.50 for the same animal in January." District number four, which is the smaller of the two districts paying bounty on muskrats, covers over 20,000 acres and has 133 miles of canals and waterways. In twelve months during 1919–20 this district, according to their secretary, paid a twenty-five cent bounty on 2395 muskrats. It is obvious that owing to the high prices of fur, nearly all of these muskrats would have been trapped, bounty or no bounty. One outstanding feature of muskrat control is seen in the fact that the market price is much more potent in the reduction of muskrats than the bounty system, and this is true even during years when fur is low in price. After careful investigation and consideration of all the factors concerned, it is believed by the writer that the value of the muskrats' pelts at least equals, and probably exceeds the damage done by these rodents in Imperial Valley.

The Imperial Valley pocket gopher constitutes the real rodent problem in the delta region. Fifteen years ago gophers occurred in very small numbers over small but widely scattered areas of the valley. This species was then so rare that museums had difficulty in securing even a few specimens. Today hundreds could be secured in almost any part of the irrigated sections. What has been the cause of this remarkable increase? The writer believes that the answer to this

question is irrigation and Bermuda grass. Under the original desert conditions food and ground suitable to burrow in were the chief factors that limited the distribution of the gopher.

Bermuda grass was abundant along the Colorado River near the intake of the main Imperial canal in 1910. This grass was carried all over the irrigated land by seed which was carried down stream by the irrigation waters. The banks of irrigation ditches afford safe breeding dens and temporary refuge to gophers. The root-stalks of the Bermuda grass, which flourishes along the margins of the canals, furnish these animals a constant, abundant, and acceptable food supply. The removal by man of many of the natural enemies of the gopher greatly improved the living conditions of these rodents, so that a larger percentage of the young reached maturity, and bred, thus hastening the rapid increase. While man has caused the death of many gophers through drowning, when the fields are flooded during irrigation, a large breeding stock always remains along the canal banks which are never flooded.

Gophers prefer to work in sandy soil. Hard or "tight" ground is avoided. This is well illustrated in districts seven and eight, both of which have a great deal of sandy ground and a corresponding abundance of gophers.

In district seven, 100 gophers have been trapped along one mile of canal in several places. In district eight, which is across the valley from district seven, there is a record of 400 gophers having been trapped in a short time along two miles of badly infested canal. Gophers are now also abundant along the main canals in Lower California. At Eastside and Sharp's headings they were found in March, 1921, to be present, as determined by actual trapping by the writer, at the rate of 105 per mile.

Gophers do not hesitate to invade fields adjoining the canals and here they destroy much alfalfa and other crops. If it were not for the fact that gophers are drowned out by flooding during irrigation they would soon become unendurable pests. There is no chance to starve out the gophers since they can always fall back on the Bermuda grass roots. The gophers often carry Bermuda grass root-stalks about in their cheek pouches and thus aid in the spread of this grass. About one-third of the gophers trapped by the writer at Eastside Heading in March, 1921, had Bermuda grass in their cheek pouches. All of the gophers thus caught were very fat, being fatter than the muskrats taken at the same time.

The breeding season of this gopher is long, extending over several months. According to professional gopher trappers two litters of young are frequently raised in one season. The average number per litter appears to be slightly less than six. As with the muskrats, the average litter is small in number, but this is more than compensated for by more than one litter being raised each season.

Unlike the muskrats, *gophers habitually burrow completely through the canal banks.* They usually keep just above the water line, but when the water in the canal is low the gophers also burrow low, and when the canal is again filled, the water leaks out through the gopher hole; this leakage, unless discovered and stopped in time, results in a break in the canal and in flooding of the surrounding fields. Gophers often burrow through the outside of the ditch banks and thus make connections with muskrat burrows, causing breaks in the canal for which the muskrat receives the blame. At the east end of the Encina flume which crosses New River below the line, gophers have riddled the inside of the main canal which at this point is merely a dirt embankment built up until the crest is nearly twenty feet above the surrounding territory. Gopher burrows in such places are exceedingly dangerous. One gopher at this point could easily endanger the growing crops on hundreds of acres in Imperial County. A narrow cement core built into the center of the canal banks could be cheaply installed at such points and would greatly reduce the danger.

Trapping and local or county bounties are the two control measures that have been most used against the gopher in this region. An officer of district eight reports that during four months in 1920–21 this district paid a bounty of twenty cents a scalp on nearly 15,000 gophers. Districts one and seven each employ two or more regular gopher catchers who are paid on a salary basis. These men trap faithfully and work where the gophers are doing the most damage, but the territory that each trapper can effectively cover is limited. The bounty system soon depletes the funds available and affords no permanent relief. Poisoning has been tried, but has met with poor success for the most part, due apparently to the abundance of food such as Bermuda grass which has been more acceptable to the gophers than the poisoned bait offered. Another difficulty is encountered in the fact that the water in the canals is used throughout the valley for domestic purposes and care must be taken that the water be not polluted by poison or by dead gophers. However, poison experiments which have already been carried on in the Imperial Valley, using a probe to locate the burrow and a bait

that is acceptable to the gopher, indicate that these rodents can be successfully poisoned. While pelts of beavers and muskrats are of considerable value, gopher pelts are worth nothing, and in the Imperial Valley these animals appear to be of no use whatever.

The rodent problems in the Imperial Valley are distinct from those that present themselves elsewhere in the state. Gopher control will be a hard fight in this section, growing harder and more expensive the longer it is put off. Any successful method of control must accord with the habits and food preference of this species, which at the present time are not well understood. A thorough study of the life history of this species should be made. The facts thus obtained, combined with actual field experiments in poisoning these rodents, would save thousands of dollars that are now being wasted in well meaning but ill-advised, unorganized, and wasteful attempts at control.

Berkeley, California.

A BROWN MUTATION IN THE OPOSSUM (DIDELPHIS VIRGINIANA) WITH REMARKS UPON THE GRAY AND THE BLACK PHASES IN THIS SPECIES[1]

By Carl Hartman

Through the courtesy of the United States Biological Survey and the United States National Museum I have been enabled to examine three brown specimens of opossums which clearly belong to the species *Didelphis virginiana.* The color of these is strikingly like the cinnamon colored mutant of the roof rat (*Rattus alexandrinus*) described by Patterson (1920) who thinks that this form may be analogous to the cinnamon mutation of the guinea pig described by Castle and Wright (1916). Like the cinnamon rat the brown opossums appeared in the wild; and since the opossum belongs to the order Marsupialia this report is not without genetic interest.

Before entering upon a detailed description of the new specimens it is necessary to recall the normal coat color of the opossum. Two phases, gray and black, have been described for the large North American opossums. In *D. marsupialis texensis* both phases are mentioned by

[1] Contribution No. 153, Zoological Laboratory, The University of Texas.